USAFA TR 2006-10

ASTM E647 FCG Testing Standard

Round Robin Fatigue Crack Growth Testing Results

Final Report

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Coordination and Approval

This article, Stress Corrosion Cracking and Repairs for Fuselage Skin Structures, is presented as a competent treatment of the subject, worthy of publication. The United States Air Force Academy vouches for the quality of the research, without necessarily endorsing the opinions and conclusions of the author. Therefore, the views expressed in this article are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the US Government.

This report has been cleared for publication and released for unlimited distribution.

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ASTM E647 FCG Round Robin Testing
Center for Aircraft Structural Life Extension (CAStLE) Lab

Introduction

The purpose of this report is to document the fatigue crack growth (FCG) testing that was accomplished, in conjunction with various other labs, to meet the objectives of the ASTM E647 FCG Round Robin Testing. Three M(T) panels each of 2024-T351 and 7075-T6 aluminum were tested, with a different configuration for each—thick panels (0.375") for 2024-T351 and thin panels (0.125") for 7075-T6. The goal of the testing was to develop da/dN vs. ΔK curves for low load ratio testing ($R = 0.1$), focusing on $\Delta K \geq 10$ ksi$\sqrt{\text{in}}$.

Testing and Results

FCG testing was accomplished, in accordance with ASTM E647, using two different capacity SATEC frames—a 20 kip test frame for the 7075-T6 panels and a 55 kip test frame for the 2024-T351 panels. Details of the testing, including both pre-crack and actual fatigue testing, are broken out below for both types of materials. Results of the testing, in terms of da/dN vs. ΔK data and curves, are provided in Attachments 1-4. Photographs of the tested specimens are provided in Attachment 5.

1) Fatigue Test Lab Information
   a. United States Air Force Academy, CAStLE Laboratory
   b. Mr. Jeff Logsdon
2) Testing Equipment and Setup
   a. SATEC
   b. 20 kip (7075-T6); 55 kip (2024-T351)
   c. Test control hardware/software
      i. Hardware: Teststar IIm
      ii. Software: Station Manager Version 3.3; MTS Fatigue Crack Growth Testware
   d. Test Specifics
      i. Load cell range/calibration
         - +/- 20 kip; calibrated 22 Sep 04
         - +/- 50 kip; calibrated 14 Sep 05
      ii. Crack Length Determination
         - Compliance
            a. Clip gage was calibrated
            b. Clip gage length: 5 mm
         - Visual Techniques
            a. Gaertner microscope + slide rail
            b. Resolution: +/- 0.004 in
      iii. Environmental Conditions
         - AL-2-22: 19-21 June 06/3 days duration

a. Temperature—26°C
b. Humidity—24%

- AL-2-29: 22-23 June 06/2 days duration
  a. Temperature—26°C
  b. Humidity—24%
- AL-2-30: 26-27 June 06/2 days duration
  a. Temperature—26°C
  b. Humidity—24%
- AL-7-32: 17-18 May 05/2 days duration
  a. Temperature—28°C
  b. Humidity—15%
- AL-7-33: 18-19 May 05/2 days duration
  a. Temperature—29°C
  b. Humidity—16%
- AL-7-34: 23-24 May 05/2 days duration
  a. Temperature—31°C
  b. Humidity—20%

iv. Grips—M(T) Geometry
- Grip-to-Grip distance – required that Gage Length ≥ 6 inches was required
- Applied strain gages to verify that no significant bending stress was present in test frame for 2024-T351 testing

3) Specimen Details
   a. Material
      i. 2024-T351 Aluminum: cracks checked visually, E not needed
      ii. 7075-T6 Aluminum: $E = 9.5 \times 10^3$ Ksi
   b. Specimen Geometry
      i. M(T) Fatigue Crack Growth Specimens
      - E647 stress intensity solution was not used. The following stress intensity solution was used, where $\Delta K = K_{max} - K_{min}$:
        a. $K = FSg\sqrt{\Pi a}$
        b. $F = \dfrac{1 - 0.5\alpha + 0.326\alpha^2}{\sqrt{1-\alpha}}$ where: $\alpha = \dfrac{a}{b}$

      ii. Dimensions
      - Width (W); Thickness (B)
        a. 2024-T351: W = 4 in; B = 0.375 in
        b. 7075-T6: W = 4 in; B = 0.125 in
      - Notch Length = 0.80 in
      - Notch Height = 0.01 in
      - Crack Length Transducer location and dimensions
        a. Crack length transducer was centered and located directly above the EDM notch
        b. Transducer was positioned with one hole approximately 0.30" above and below the EDM notch

iii. Specimen Preparation
- Specimen surfaces were minimually polished with a machine buffer to facilitate visual crack length measurements
- EDM notch was used
- Specimens were cut in length to facilitate the minimum gage length ≥ 1.5 W; therefore gage length = 6 inches between grip holes

4) Test Procedure Details
a. Precracking
i. Overall precracking procedures
- Utilized constant ΔK
- FCGR at end of precracking
  a. AL-2-22: $da/dN = 3.35 \times 10^{-6}$ in/cycle
  b. AL-2-29: $da/dN = 1.05 \times 10^{-6}$ in/cycle
  c. AL-2-30: $da/dN = 6.88 \times 10^{-7}$ in/cycle
  d. AL-7-32: undetermined
  e. AL-7-33: undetermined
  f. AL-7-34: undetermined

ii. Loading conditions for precracking
- P_{max} = 7 kip (2024-T351) & 2 kip (7075-T6); $R = 0.1$
- Test Frequency = 15 hz
- Initial and Final Crack Lengths
  a. AL-2-22: $a_i = 0.4$ in; $a_f = 0.446$ in
  b. AL-2-29: $a_i = 0.4$ in; $a_f = 0.440$ in
  c. AL-2-30: $a_i = 0.4$ in; $a_f = 0.442$ in
  d. AL-7-32: $a_i = 0.4$ in; $a_f = 0.527$ in
  e. AL-7-33: $a_i = 0.4$ in; $a_f = 0.542$ in
  f. AL-7-34: $a_i = 0.4$ in; $a_f = 0.506$ in
- Initial and Final ΔK levels
  a. AL-2-22: $\Delta K_i = 4.81$ ksi$\sqrt{}$in; $\Delta K_f = 5.52$ ksi$\sqrt{}$in
  b. AL-2-29: $\Delta K_i = 4.81$ ksi$\sqrt{}$in; $\Delta K_f = 5.49$ ksi$\sqrt{}$in
  c. AL-2-30: $\Delta K_i = 4.81$ ksi$\sqrt{}$in; $\Delta K_f = 5.50$ ksi$\sqrt{}$in
  d. AL-7-32: $\Delta K_i = 4.04$ ksi$\sqrt{}$in; $\Delta K_f = 5.15$ ksi$\sqrt{}$in
  e. AL-7-33: $\Delta K_i = 4.04$ ksi$\sqrt{}$in; $\Delta K_f = 5.22$ ksi$\sqrt{}$in
  f. AL-7-34: $\Delta K_i = 4.04$ ksi$\sqrt{}$in; $\Delta K_f = 5.04$ ksi$\sqrt{}$in

iii. Crack Tip Symmetry

Specimen ID	$a_{front, left}$ (in)	$a_{front, right}$ (in)	$a_{back, left}$ (in)	$a_{back, right}$ (in)
AL-2-22	0.438	0.436	0.442	0.466
AL-2-29	0.437	0.429	0.450	0.444
AL-2-30	0.443	0.440	0.438	0.446
AL-7-32	0.545	0.520	0.521	0.520
AL-7-33	0.521	0.563		
AL-7-34	0.505	0.517	0.498	0.502

b. Fatigue Crack Growth Testing
   i. Approach
      - Constant Amplitude: 2024-T351 panels
        a. P_{max} = 10.5 kip; R = 0.1; Frequency = 15 hz
        b. Initial and Final Crack Lengths
           i. AL-2-22: a_i = 0.446 in; a_f = 1.642 in
           ii. AL-2-29: a_i = 0.440 in; a_f = 1.646 in
           iii. AL-2-30: a_i = 0.442 in; a_f = 1.631 in
        c. Initial and Final ΔK levels
           i. AL-2-22: ΔK_i = 5.52 ksi$\sqrt{}$in; ΔK_f = ksi$\sqrt{}$in
           ii. AL-2-29: ΔK_i = 5.49 ksi$\sqrt{}$in; ΔK_f = ksi$\sqrt{}$in
           iii. AL-2-30: ΔK_i = 5.50 ksi$\sqrt{}$in; ΔK_f = ksi$\sqrt{}$in
        d. $\Delta a/W$ crack length intervals for data points
           i. $\Delta a \leq 0.03W$ for $2a/W < 0.60$
           ii. $\Delta a \leq 0.02W$ for $2a/W > 0.60$
        e. visual crack length intervals and number of visuals taken, and crack tip symmetry are included as Attachment 1.
      - K-control—7075-T6 panels
        a. Initial Stress intensity
           i. AL-7-32: $K_{initial}$ = 5.21 ksi$\sqrt{}$in
           ii. AL-7-33: $K_{initial}$ = 4.82 ksi$\sqrt{}$in
           iii. AL-7-34: $K_{initial}$ = 5.48 ksi$\sqrt{}$in
        b. Normalized K-gradient—2.5
        c. R = 0.1; Frequency = 15 hz
        d. Initial and Final Crack Lengths
           i. AL-7-32: a_i = 0.527 in; a_f = 1.351 in
           ii. AL-7-33: a_i = 0.542 in; a_f = 1.615 in
           iii. AL-7-34: a_i = 0.506 in; a_f = 1.376 in
        e. $\Delta a/W$ crack length intervals for data points—it appears to be 0.005
        f. Crack length data included as Attachment 2

5) Analysis Technique (post-test processing)
   a. Automated/manual
      i. 2024-T351—manual, using
         - $K = FSg\sqrt{\Pi a}$
         - $F = \dfrac{1 - 0.5\alpha + 0.326\alpha^2}{\sqrt{1-\alpha}}$ where: $\alpha = \dfrac{a}{b}$
      ii. 7075-T6—automated, utilizing MTS Fatigue Crack Growth Testware
   b. Method used: Secant method
   c. Crack front profile and final crack length measurements are included in Attachments 3 and 4
   d. Possible error between visual crack lengths and transducer crack lengths was not investigated

e. No fracture surface appearance anomalies were observed
f. Validation of yield criteria for both materials was determined, in accordance with ASTM E647

This concludes CAStLE's portion of the round robin testing. For any questions or concerns, please feel free to contact me.

Maj Jason Avram
CAStLE Deputy for Research

Attachments:
1. 2024-T351 Crack Growth Data
2. 7075-T6 Crack Growth Data
3. 2024-T351 da/dN Data
4. 7075-T6 da/dN Data
5. Photograph of Tested FCG Panels

Attachment 1: 2024-T351 Crack Growth Data

AL-2-22 FCG Panel					
	Left Crack Tip	Left Crack Tip	Right Crack Tip	Right Crack Tip	Avg. Crack Length
Cycles	Front (in)	Back (in)	Front (in)	Back (in)	(inches)
30000	0.438	0.442	0.441	0.471	**0.448**
60000	0.446	0.449	0.451	0.471	**0.45425**
100000	0.458	0.47	0.457	0.472	**0.46425**
140000	0.481	0.473	0.476	0.505	**0.48375**
160000	0.494	0.492	0.479	0.505	**0.4925**
180000	0.527	0.56	0.526	0.567	**0.545**
200000	0.631	0.667	0.64	0.674	**0.653**
210000	0.705	0.742	0.72	0.759	**0.7315**
220000	0.807	0.838	0.824	0.863	**0.833**
230000	0.943	0.972	0.953	0.998	**0.9665**
235000	1.028	1.054	1.043	1.081	**1.0515**
240000	1.121	1.137	1.142	1.171	**1.14275**
245000	1.265	1.288	1.296	1.319	**1.292**
248000	1.406	1.431	1.429	1.431	**1.42425**
249000	1.485	1.511	1.504	1.528	**1.507**
249500	1.537	1.575	1.566	1.591	**1.56725**
250000	1.622	1.646	1.641	1.66	**1.64225**

AL-2-29 FCG Panel					
	Left Crack Tip	Left Crack Tip	Right Crack Tip	Right Crack Tip	Avg. Crack Length
Cycles	Front (in)	Back (in)	Front (in)	Back (in)	(inches)
30000	0.519	0.569	0.508	0.545	**0.53525**
50000	0.631	0.678	0.633	0.668	**0.6525**
60000	0.712	0.763	0.698	0.748	**0.73025**
70000	0.801	0.862	0.806	0.851	**0.83**
80000	0.942	0.986	0.952	0.981	**0.96525**
85000	1.022	1.066	1.038	1.074	**1.05**
90000	1.124	1.162	1.136	1.184	**1.1515**
93000	1.196	1.239	1.235	1.281	**1.23775**
95000	1.245	1.283	1.34	1.336	**1.301**
97000	1.329	1.361	1.415	1.413	**1.3795**
98000	1.371	1.401	1.476	1.461	**1.42725**
99500	1.49	1.509	1.62	1.601	**1.555**
100000	1.554	1.581	1.742	1.705	**1.6455**

AL-2-30 FCG Panel					
	Left Crack Tip	Left Crack Tip	Right Crack Tip	Right Crack Tip	Avg. Crack Length
Cycles	Front (in)	Back (in)	Front (in)	Back (in)	(inches)
30000	0.531	0.535	0.53	0.535	**0.53275**
50000	0.657	0.652	0.656	0.658	**0.65575**
60000	0.737	0.733	0.738	0.741	**0.73725**
70000	0.851	0.848	0.851	0.852	**0.8505**
77000	0.946	0.93	0.955	0.952	**0.94575**
84000	1.075	1.055	1.064	1.065	**1.06475**
89000	1.184	1.168	1.179	1.179	**1.1775**
92000	1.254	1.27	1.272	1.253	**1.26225**
94000	1.328	1.327	1.34	1.31	**1.32625**
95500	1.416	1.401	1.417	1.366	**1.4**
96500	1.468	1.452	1.459	1.425	**1.451**
97500	1.545	1.534	1.525	1.511	**1.52875**
98200	1.65	1.65	1.612	1.611	**1.63075**

Attachment 2: 7075-T6 Crack Growth Data

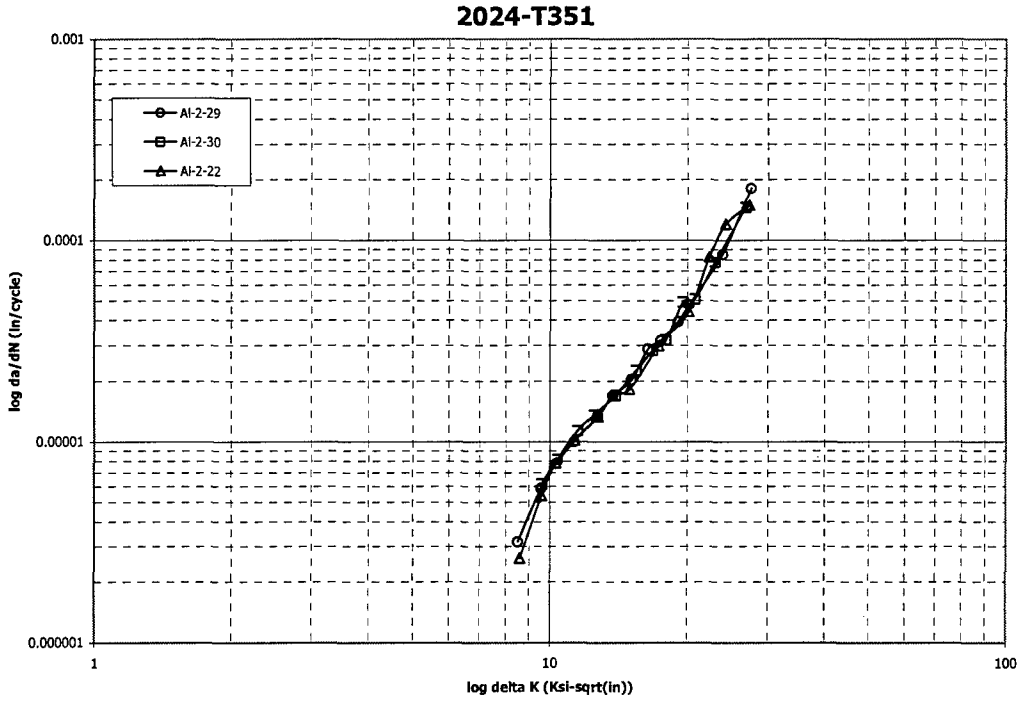
AL-7-32 FCG Panel		AL-7-33 FCG Panel		AL-7-34 FCG Panel	
	Crack Length		Crack Length		Crack Length
Cycles	(in)	Cycles	(in)	Cycles	(in)
75	0.530343	83	0.515134	96	0.556429
22113	0.551661	11832	0.535358	38175	0.576772
49194	0.572579	41057	0.555382	64964	0.597374
68391	0.592614	72653	0.575512	86495	0.618142
81697	0.613032	95415	0.596917	101346	0.638165
93187	0.634543	115222	0.617358	111140	0.658311
105072	0.65485	131794	0.637398	120179	0.67985
114599	0.675476	144841	0.657693	126684	0.700846
123658	0.695524	155628	0.67935	132231	0.720882
129597	0.716402	166158	0.699689	135988	0.741035
135786	0.736402	174511	0.719705	139466	0.761484
141082	0.756949	181515	0.740677	142268	0.781898
145107	0.778059	186471	0.761138	145230	0.80213
148547	0.799118	191126	0.781681	147551	0.823181
151846	0.819362	195441	0.802004	149983	0.843949
154248	0.840063	198964	0.822173	152117	0.865169
156557	0.860843	202117	0.842248	154029	0.885622
158919	0.881811	204996	0.862382	155673	0.905949
161370	0.901909	207440	0.882894	157145	0.926028
163212	0.922331	209667	0.902969	158383	0.946555
164935	0.942488	211349	0.92335	159672	0.966595
166471	0.962539	213070	0.943701	160775	0.987567
167723	0.983091	214582	0.963811	161845	1.00763
169161	1.00365	216067	0.984673	162706	1.02771
170283	1.02392	217362	1.00498	163502	1.04822
171465	1.04404	218499	1.02552	164295	1.06836
172449	1.0642	219573	1.04588	165052	1.08889
173267	1.08519	220564	1.0659	165790	1.10898
174091	1.10581	221493	1.08591	166409	1.12938
174821	1.12678	222404	1.10669	167025	1.14946
175451	1.14682	223277	1.12748	167616	1.17054
176019	1.16692	224037	1.148	168160	1.19067
176530	1.18706	224701	1.16835	168621	1.21069
176898	1.20709	225289	1.18846	169098	1.23107
177293	1.22713	225746	1.20853	169537	1.25117
177608	1.24745	226163	1.22886	169875	1.27124
177863	1.26753	226537	1.24943	170134	1.29141
178060	1.28811	226810	1.2698	170363	1.31268
178241	1.3088	227025	1.29014	170542	1.33492
178376	1.33009	227215	1.31018	170673	1.35555
178481	1.35062	227346	1.33101	170772	1.37597
		227467	1.35103		
		227564	1.38501		
		227737	1.40632		
		227821	1.42876		
		227873	1.45004		
		227915	1.4739		
		227948	1.49939		
		227971	1.52209		
		227982	1.54669		
		228005	1.61511		

Attachment 3: 2024-T351 da/dN Data

AL-2-22 FCG Data				
	da/dN	alpha	F	delta K
Cycles	(in/cycle)			(ksi-sqrt(in)
0		0.22275	1.026295	
30000	8.33E-08	0.224	1.026619	5.480696
60000	2.08E-07	0.227125	1.027438	5.523195
100000	2.5E-07	0.232125	1.028779	5.590946
140000	4.88E-07	0.241875	1.031504	5.722278
160000	4.37E-07	0.24625	1.032776	5.780916
180000	2.63E-06	0.2725	1.04106	8.582018
200000	5.4E-06	0.3265	1.061939	9.582346
210000	7.85E-06	0.36575	1.080785	10.32195
220000	1.02E-05	0.4165	1.110529	11.31796
230000	1.34E-05	0.48325	1.160885	12.744
235000	0.000017	0.52575	1.201228	13.75453
240000	1.83E-05	0.571375	1.253625	14.96438
245000	2.99E-05	0.646	1.36651	17.34442
248000	4.41E-05	0.712125	1.508293	20.09992
249000	8.28E-05	0.7535	1.628118	22.31814
249500	0.000121	0.783625	1.737835	24.29368
250000	0.00015	0.821125	1.91339	27.38032

AL-2-29 FCG Data				
	da/dN	alpha	F	delta K
Cycles	(in/cycle)			(ksi-sqrt(in)
0		0.22	1.025592	
30000	3.175E-06	0.267625	1.039434	8.491627
50000	5.8625E-06	0.32625	1.06183	9.577688
60000	7.775E-06	0.365125	1.080458	10.31001
70000	9.975E-06	0.415	1.109554	11.28763
80000	1.3525E-05	0.482625	1.160344	12.72982
85000	0.00001695	0.525	1.200451	13.73582
90000	0.0000203	0.57575	1.259226	15.08867
93000	0.00002875	0.618875	1.320836	16.40896
95000	3.1625E-05	0.6505	1.374691	17.50891
97000	0.00003925	0.68975	1.454614	19.07761
98000	0.00004775	0.713625	1.512139	20.17239
99500	8.5167E-05	0.7775	1.713633	23.86154
100000	0.000181	0.82275	1.922279	27.53474

AL-2-30 FCG Data				
	da/dN	alpha	F	delta K
Cycles	(in/cycle)			(ksi-sqrt(in)
30000		0.266375	1.039024	
50000	6.15E-06	0.327875	1.062544	9.607971
60000	8.15E-06	0.368625	1.0823	10.37697
70000	1.13E-05	0.42525	1.116347	11.49614
77000	1.36E-05	0.472875	1.152095	12.51099
84000	0.000017	0.532375	1.208205	13.92131
89000	2.26E-05	0.58875	1.276533	15.46779
92000	2.83E-05	0.631125	1.340723	16.82005
94000	3.2E-05	0.663125	1.398653	17.98614
95500	4.92E-05	0.7	1.478376	19.5328
96500	5.1E-05	0.7255	1.543802	20.76542
97500	7.78E-05	0.764375	1.66515	22.9899
98200	0.000146	0.815375	1.88291	26.84966



Attachment 4: 7075-T6 da/dN Data

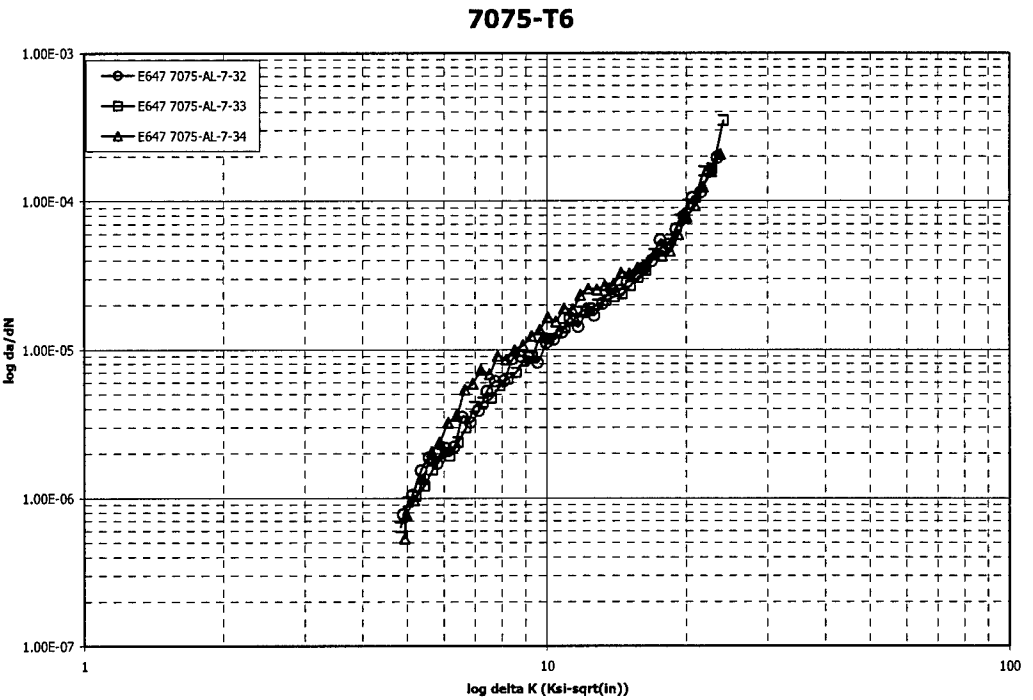
AL-7-32 FCG Panel			
		Delta K	Delta K
	da/dN	Applied	Effective
Cycles	(in/cycle)	Ksi(in^.5)	Ksi(in^.5)

11094	9.67E-07	4.685651	4.50331
35653	7.72E-07	4.896913	4.573674
58792	1.04E-06	5.12104	4.96342
75044	1.53E-06	5.348073	5.273048
87442	1.87E-06	5.564574	5.088261
99129	1.71E-06	5.79365	5.374089
109835	2.17E-06	6.047735	5.578877
119128	2.21E-06	6.304612	5.553465
126627	3.52E-06	6.568769	6.150474
132691	3.23E-06	6.836207	6.600224
138434	3.88E-06	7.11861	6.913334
143094	5.24E-06	7.414769	7.259222
146827	6.12E-06	7.727275	7.639184
150196	6.14E-06	8.074084	7.323599
153047	8.62E-06	8.412778	7.682467
155402	9.00E-06	8.757716	8.46573
157738	8.88E-06	9.1308	7.949934
160144	8.20E-06	9.539281	8.602312
162291	1.11E-05	9.958958	9.32117
164073	1.17E-05	10.34965	9.729075
165703	1.31E-05	10.76251	10.02336
167097	1.64E-05	11.2086	9.655662
168442	1.43E-05	11.68546	9.620322
169722	1.81E-05	12.1635	10.53171
170874	1.70E-05	12.64433	12.25859
171957	2.05E-05	13.1803	13.10159
172858	2.57E-05	13.76192	13.68827
173679	2.50E-05	14.34715	13.15921
174456	2.87E-05	14.91668	13.42613
175136	3.18E-05	15.54796	14.0265
175735	3.54E-05	16.21568	13.93033
176274	3.94E-05	16.84881	15.79693
176714	5.44E-05	17.56827	10.52601
177095	5.07E-05	18.30008	11.10581
177450	6.45E-05	19.01462	10.82433
177735	7.87E-05	19.78067	3.187272
177961	1.05E-04	20.60443	9.170169
178150	1.14E-04	21.50913	15.7217
178308	1.58E-04	22.43353	16.80291
178428	1.96E-04	23.32457	9.727608

AL-7-33 FCG Data			
		Delta K	Delta K
	da/dN	Applied	Effective
Cycles	(in/cycle)	Ksi(in^.5)	Ksi(in^.5)

5957	1.72E-06	4.338151	2.78633
26444	6.85E-07	4.631921	4.612697
56855	6.37E-07	4.831874	4.805945
84034	9.40E-07	5.019136	4.914727
105318	1.03E-06	5.21034	5.103054
123508	1.21E-06	5.43792	5.317942
138317	1.56E-06	5.66596	5.494095
150234	2.01E-06	5.908563	5.736698
160893	1.93E-06	6.168259	5.912275
170334	2.40E-06	6.430374	6.035476
178013	2.99E-06	6.692574	6.391897
183993	4.13E-06	6.974114	6.695711
188798	4.41E-06	7.275338	6.824092
193283	4.71E-06	7.586433	7.188312
197202	5.73E-06	7.903917	7.142065
200540	6.37E-06	8.232538	7.289641
203556	6.99E-06	8.573045	7.910766
206218	8.39E-06	8.914818	8.419771
208553	9.01E-06	9.287326	8.620443
210508	1.21E-05	9.67949	8.40095
212209	1.18E-05	10.09623	8.72324
213826	1.33E-05	10.51631	9.035658
215324	1.40E-05	10.93532	9.610335
216714	1.57E-05	11.39256	9.427794
217930	1.81E-05	11.8689	9.441694
219036	1.90E-05	12.3619	10.4557
220068	2.02E-05	12.87347	10.98186
221028	2.15E-05	13.41511	11.87713
221948	2.28E-05	13.97439	11.90714
222840	2.38E-05	14.53643	11.30726
223657	2.70E-05	15.1505	12.9531
224369	3.06E-05	15.72648	15.12409
224995	3.42E-05	16.34124	15.58618
225517	4.39E-05	17.05403	16.5643
225954	4.88E-05	17.76336	16.04632
226350	5.50E-05	18.53756	15.35086
226673	7.46E-05	19.35717	16.14117
226917	9.46E-05	20.1501	15.71137
227120	1.05E-04	20.9451	15.1025
227280	1.59E-04	21.83027	15.12699
227406	1.65E-04	22.74134	16.14365
227515	3.50E-04	24.04489	20.91779
227650	1.23E-04	25.45607	25.41955
227779	2.67E-04	26.52318	21.47371
227847	4.09E-04	27.59278	20.5018
227894	5.68E-04	28.78767	23.26079
227931	7.72E-04	30.14975	24.04207
227959	9.87E-04	31.52479	28.99257
227976	2.24E-03	32.77694	32.75794
227993	2.98E-03	35.14425	35.08554

AL-7-34 FCG Data		
		Delta K
	da/dN	Applied
Cycles	(in/cycle)	(Ksi/in^1.5)
-------	----------	
19135	5.34E-07	4.93647
51569	7.69E-07	4.98167
75729	9.65E-07	5.17281
93920	1.35E-06	5.40422
106243	2.06E-06	5.63887
115659	2.38E-06	5.8671
123431	3.23E-06	6.11808
129457	3.61E-06	6.38075
134109	5.36E-06	6.64654
137727	5.88E-06	6.92004
140867	7.29E-06	7.20312
143749	6.83E-06	7.51153
146390	9.07E-06	7.82797
148767	8.54E-06	8.15539
151050	9.94E-06	8.51489
153073	1.07E-05	8.88252
154851	1.24E-05	9.25361
156409	1.36E-05	9.64986
157764	1.66E-05	10.0407
159027	1.55E-05	10.441
160223	1.90E-05	10.8891
161310	1.88E-05	11.3533
162275	2.33E-05	11.811
163104	2.58E-05	12.2926
163898	2.54E-05	12.8107
164673	2.71E-05	13.3429
165421	2.72E-05	13.8966
166099	3.30E-05	14.4798
166717	3.26E-05	15.07
167320	3.57E-05	15.6922
167888	3.70E-05	16.3547
168390	4.34E-05	17.0304
168859	4.27E-05	17.7388
169317	4.58E-05	18.4749
169706	5.94E-05	19.239
170004	7.79E-05	20.0563
170248	9.29E-05	20.9056
170452	0.000124	21.7621
170607	0.000157	22.6827
170722	0.000206	23.6929


7075-T6
E647 7075-AL-7-32
E647 7075-AL-7-33
E647 7075-AL-7-34
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
log da/dN
1
10
100
log delta K (Ksi-sqrt(in))

Attachment 5: Photograph of Tested FCG Panels

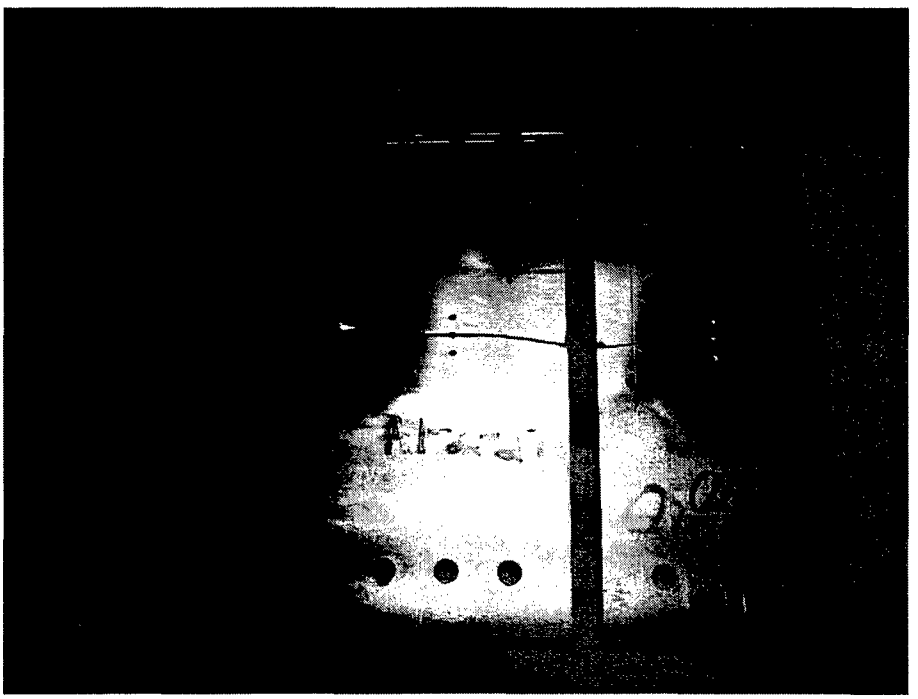


Figure 1: Photograph of Tested 2024-T351 FCG Panels

Figure 2: Photograph of Tested 7075-T6 FCG Panels

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14. ABSTRACT
The purpose of this report is to document the fatigue crack growth (FCG) testing that was accomplished, in conjunction with various other labs, to meet the objectives of the ASTM E647 FCG Round Robin Testing. Three M(T) panels each of 2024-T351 and 7075-T6 aluminum were tested, with a different configuration for each—thick panels (0.375") for 2024-T351 and thin panels (0.125") for 7075-T6. The goal of the testing was to develop da/dN vs. ΔK curves for low load ratio testing ($R = 0.1$), focusing on $\Delta K \geq 10$ ksi$\sqrt{}$in.

15. SUBJECT TERMS
Fatigue crack growth, ASTM, Testing standard, da/dN vs. ΔK

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